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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [4]: B23K 26/00, 26/14	A1	(11) International Publication Number: WO 89/ 03274
		(43) International Publication Date: 20 April 1989 (20.04.89)

(21) International Application Number: PCT/DK87/00124

(22) International Filing Date: 14 October 1987 (14.10.87)

(71) Applicant *(for all designated States except US)*: AKADEMIET FOR DE TEKNISKE VIDENSKABER, SVEJSECENTRALEN [DK/DK]; 345 Park Allé, DK-2605 Broendby (DK).

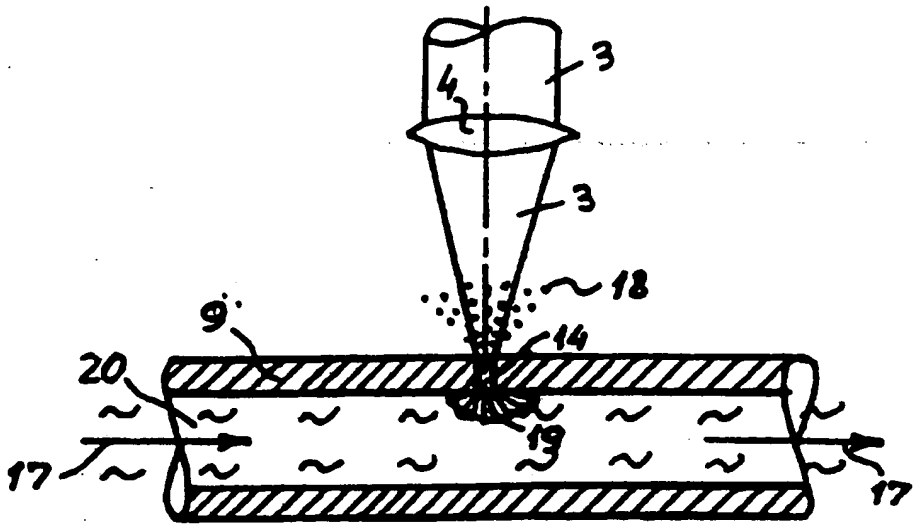
(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : NIELSEN, Steen, Erik [DK/DK]; 4 Nyvej, DK-3320 Skaevinge (DK).

(74) Agent: INTERNATIONALT PATENT-BUREAU; 12 Nybrogade, DK-1203 Copenhagen K (DK).

(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), DK, FI, FR (European patent), GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), NO, SE (European patent), SU, US.

Published
With international search report.

(54) Title: METHOD AND APPLICATION OF LASER DRILLING



(57) Abstract

An improved method and application of laser drilling of narrow holes (14) through solid, e.g. metallic, ceramic or thermoplastic objects (2, 20), comprises the step of sluicing or flushing the back of said object during the drilling operation with a backing fluid under pressure (15, 17), preferably pure water or a pure inert gas. In laser drilling of narrow holes (14) through the wall of tubular objects (20), said backing fluid is passed through said tubular object during the drilling operation. A particularly advantageous application of the invention is the manufacture of narrow holes (14) through small-diameter, thin-walled injection needles (20) for medical use, such needles having typically a wall thickness of 0.1 mm, perforated by a number of holes (14) of 0.05 mm diameter or less.

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METHOD AND APPLICATION OF LASER DRILLING

BACKGROUND OF THE INVENTION

1. Field of the invention

This invention relates to the method of producing narrow holes through an object by the application of laser drilling. The invention relates in particular to the perforation of solid objects of e.g. metallic, ceramic or thermoplastic materials, more particularly to the perforation of the wall of tubular objects, and most particularly to the perforation of the wall of injection needles for medical use.

The invention further relates to objects perforated by one or more narrow holes by application of the invented method of laser drilling, in particular to perforated injection needles for medical use. Injection needles of this kind may typically have a stainless steel wall of a thickness of 0.1 mm perforated by a number of holes of 0.05 mm diameter or less.

2. Background of the Prior Art

Laser drilling is normally performed by focusing an intense laser beam on the surface of the object where the perforation has to take place. At the same time, a gas nozzle may blow an auxiliary drilling gas against said surface of the object to remove the molten and/or evaporated material. Normally, oxygen is used, but in cases where an oxidation of the object must be avoided, an inert gas, such as argon, may be used. For precision drilling of narrow holes through thin-walled objects it is normal to use a pulsed laser beam for the focusing of a well-defined amount of energy which is just sufficient to melt and/or evaporate the material struck by the

laser beam. The geometry and diameter of the hole can be adjusted by adjustments in energy or focusing. During the actual drilling of the hole, molten and/or evaporated material is ejected from the hole, first upwards and later downwards through the hole at the burn-through of the laser beam. The geometry of the hole may vary from cylindrical to conically convergent or divergent. A small flash or burr of molten material is normally formed along the edge of the hole.

Where high precision and cleanness is required, the molten and/or evaporated spatter material and the flash or burr formation are major disadvantages of the art. This is more particularly the case in the perforation of one wall of injection needles, where the removal of spatter from the external and internal surfaces necessitates complicated cleaning operations. The outside burr formation must further be reduced in order to reduce the pain at the injection of the needle, and in order to reduce damage to a surface coating, if any, e.g. a silicone coating of the needle. A further serious disadvantage is the difficulty of avoiding a perforation or contamination of the opposite wall of small-diameter thin-walled objects.

SUMMARY OF THE INVENTION

The laser drilling method according to the present invention has been evolved with the general object of overcoming the disadvantages of the prior art by providing significantly improved precision in the geometry of the holes, and significantly improved cleanness of the surfaces of the perforated objects.

According to the present invention there is provided a sluicing or flushing of the back of the object during the drilling operation with a backing fluid under pressure, preferably pure water or a pure inert gas. The pressure of said backing fluid will blow the molten and/

or evaporated spatter material upwards and out through the hole at the moment of beam penetration. When water or a similar fluid is used, the instant heating and the sudden formation of the added pressure in a local vapour bubble at the inner surface of the object will greatly increase the cleaning effect. At the same time, the formation of a flash or burr along the edges of the hole will be significantly reduced due to the cooling effect of the fluid.

The method according to the present invention is particularly advantageous in the laser perforation of one wall of tubular objects, where the backing fluid passed through the tube will effectively prevent perforation or contamination of the opposite wall of the tubular object. At the same time, the cooling fluid will stabilize the drilling process as a whole, and make the laser parameters less sensitive to small variations and irregularities, a fact of great importance in a production situation.

The method according to the present invention is more particularly advantageous in the perforation of thin-walled injection needles for medical use, where the internal fluid will carry away any residual spatter or other impurities formed inside the needle.

Other objects and advantages will be readily apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic presentation of the main principles of prior art in a first method of laser drilling of narrow holes through an object;

Figure 2 is a schematic presentation of the main principles of prior art in a second method of laser drilling of narrow holes through an object;

Figure 3 is a schematic presentation of the main

principles of prior art in laser drilling of narrow holes through the wall of tubular objects;

Figure 4 is a schematic presentation of the main principles of the invented method of laser drilling of narrow holes through an object; and

Figure 5 is a schematic presentation of the main principles of the invented method of laser drilling of narrow holes through one wall of a tubular object.

DETAILED DESCRIPTION OF THE INVENTED METHODS

Figure 1 shows schematically the main principles of prior art in a first method of laser drilling of narrow holes 1 through a solid object 2. The object 2 may be of any solid material, e.g. metallic, ceramic or thermoplastic. An intense laser beam 3 is focused by an optical lens 4 on or slightly below the surface of the object 2 where the perforation has to take place. At the same time, an excentric gas nozzle 5 blows an auxiliary drilling gas 6 against the surface of the object to remove the molten and/or evaporated material. Normally, oxygen is used, but in cases where an oxidation of the object must be avoided, an inert cover gas, such as argon, may be used.

Figure 2 shows schematically the main principles of a second method of laser drilling, where a concentric nozzle 7 blows an auxiliary drilling gas 8 against the surface of the object 2.

Figure 3 shows schematically the main principles of prior art in laser drilling of narrow holes through the irradiated wall 9 of a tubular object 20.

For precision drilling of narrow holes it is normal to use a pulsed laser beam 3 for the focusing of a well-defined amount of energy which is just sufficient to melt and/or evaporate the material struck by the laser beam 3. The geometry and diameter of the hole 1 can be adjusted by adjustments in energy or focusing. During the actual drilling of the hole, molten and/or evaporated

spatter material is ejected from the hole 1, first upwards 10 and later downwards 11 through the hole at the burn-through of the laser beam. The geometry of the hole may vary from cylindrical to conically convergent or divergent. A small flash or burr 12 is normally formed along the edges of the hole. A major disadvantage of prior art is the formation of spatter material 11 inside the tubular object 20, and the difficulty of avoiding a contamination 11 or perforation 13 of the opposite wall of small-diameter tubular objects 20 such as thin-walled injection needles.

Figure 4 shows schematically the main principles of the invented method of laser drilling of narrow holes 14 through a solid object 2. According to the invention there is provided a sluicing or flushing of the back of the object during the drilling operation with a backing fluid under pressure 15, preferably pure water or a pure inert gas from a nozzle 16. The pressure of said backing fluid 15 will blow the molten and/or evaporated material upwards and out through the hole 14 at the moment of beam-penetration.

Figure 5 shows schematically the main principles of the invented method of laser drilling of narrow holes through the irradiated wall 9 of a tubular object 20. According to the invention there is provided a sluicing or flushing of the inside of the tube wall 9 during the drilling operation with a backing fluid under pressure 17, preferably pure water or a pure inert gas which is passed through the tubular object 20. The backing fluid 17 will blow the molten and/or evaporated material 18 out through the hole at the moment of beam penetration. When water or a similar fluid is used, the instant heating and the sudden formation of added pressure in a local vapour bubble 19 at the inner surface of the object will greatly increase the cleaning effect. At the same

time, the backing fluid will effectively prevent the contamination 11 or perforation 13 of the opposite wall of small-diameter objects 20 such as thin-walled injection needles. The formation of a flash or burr 12 along the edges of the hole will be significantly reduced due to the cooling effect of the backing fluid 17, the internal cooling fluid 17 will stabilize the drilling process as a whole, and the internal fluid 17 will carry away any residual material spatter or other impurities formed inside the needle.

It will be readily apparent that the invented method illustrated in figures 4 and 5 may or may not be supplemented by a prior art external cover gas 6 or 8 as illustrated in figures 1 and 2.

It will be understood that several modifications and variations of the described method may be effected without departing from the spirit and scope of the novel concepts of the present invention.

PATENT CLAIMS

1. An improved method of laser drilling of narrow holes (14) through an object (2, 20), comprising the step of sluicing the back of said object during the drilling operation with a backing fluid under pressure (15, 17).

2. The method of claim 1 for laser drilling of narrow holes (14) through the wall of a tubular object (20) wherein said backing fluid (17) is passed through said tubular object (20) during the drilling operation.

3. The method of claim 2 wherein said tubular object (20) is an injection needle for medical use.

4. The methods of claims 1, 2 or 3 wherein said backing fluid (15, 17) is pure water or a pure inert gas.

5. An object (2, 20) perforated by one or more holes (14), said holes having been drilled by application of the methods of claims 1 or 4.

6. A tubular object (20) perforated by one or more narrow holes (14), said holes having been drilled by application of the methods of claims 2 or 4.

7. An injection needle for medical use perforated by one or more narrow holes (14), said holes having been drilled by application of the methods of claims 3 or 4.

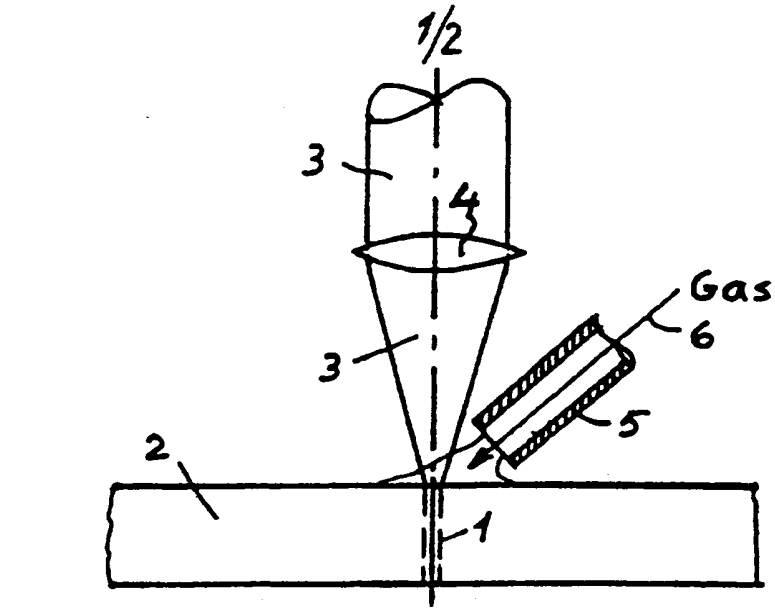

Fig 1

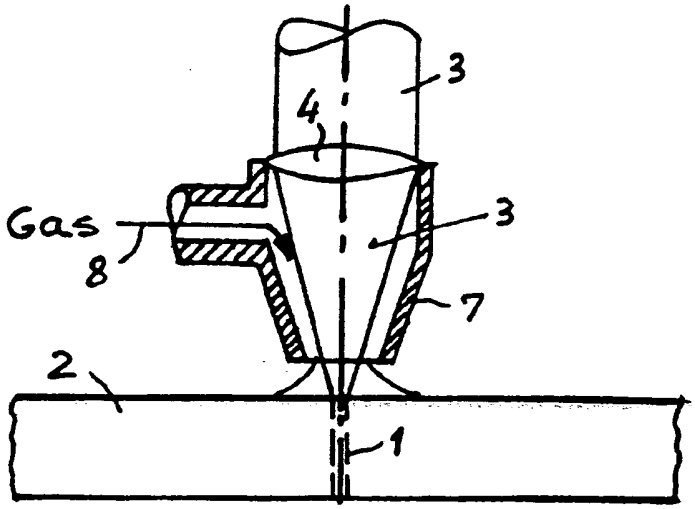

Fig 2

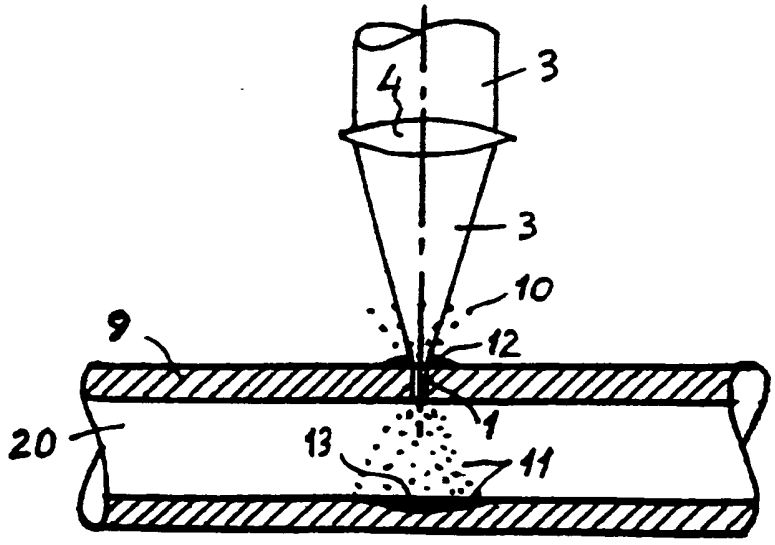

Fig 3

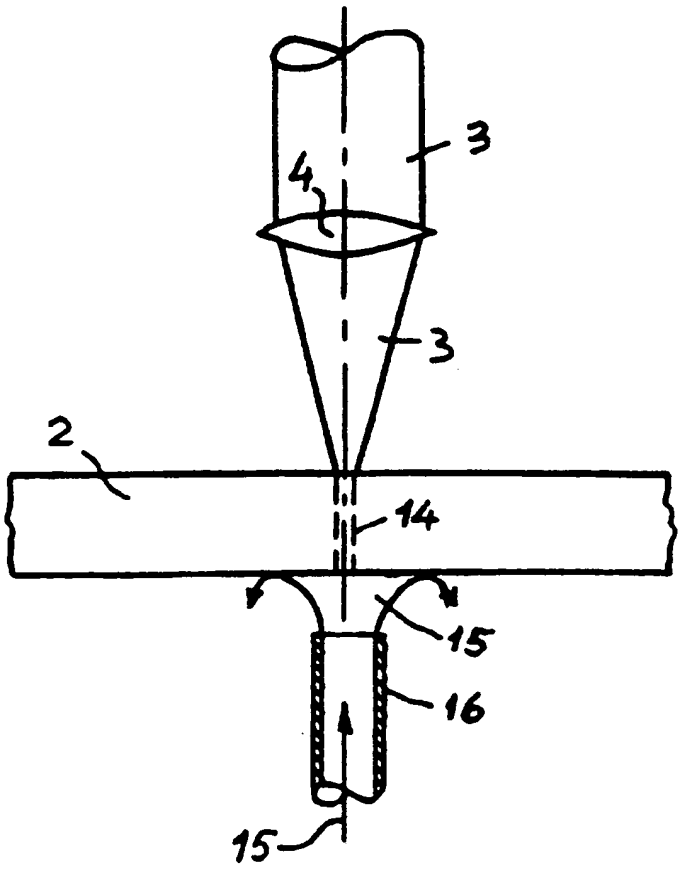

Fig 4

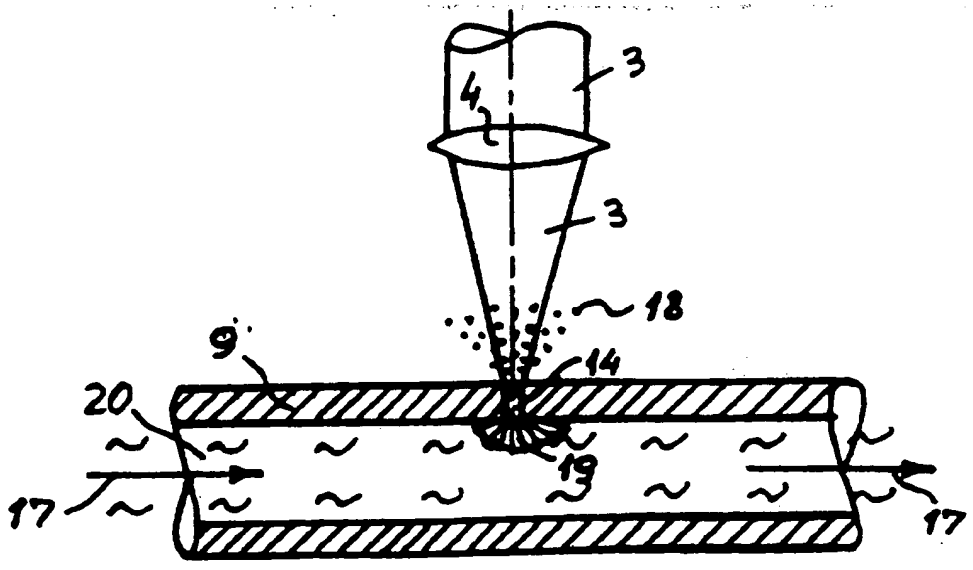

Fig 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 87/00124

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: B 23 K 26/00; B 23 K 26/14

II. FIELDS SEARCHED

Minimum Documentation Searched [7]	
Classification System	Classification Symbols
IPC[4]	B 23 K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	DE, A1, 2338514 (LKS-LASER-KOMBINATIONS-SYSTEME GmbH) 20 February 1975, see page 1, paragraph 2; page 4, paragraphs 1-4; page 7; figure 2	1,4,5
Y	--	2,6
Y	US, A, 4048464 (P.L. GALE et al.) 13 September 1977, see column 4, lines 24-33; column 6, lines 1-16; figures 2,3	2,6
A	--	1,4
X	US, A, 3601576 (H. SCHLAFLI et al.) 24 August 1971, see column 3, lines 6-19; figures 1,3	1
A	-- FR, A, 2222170 (AMERICAN CYANAMID CO.) 18 October 1974, see the whole document	1-3,5-7
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* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14th June 1988	15. 07. 88
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. DK 8700124 SA 19241

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 11/07/88
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
DE-A- 2338514	20-02-75	None		
US-A- 4048464	13-09-77	None		
US-A- 3601576	24-08-71	NL-A-	6813464	27-03-69
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		DE-A-	1790129	13-04-72
		BE-A-	721320	03-03-69
		AT-A-	296894	15-01-72
		SE-B-	353252	29-01-73
FR-A- 2222170	18-10-74	DE-A-	2413433	03-10-74
		GB-A-	1424953	11-02-76
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